

US010365084B2

(12) **United States Patent**
Little et al.

(10) **Patent No.:** **US 10,365,084 B2**
(45) **Date of Patent:** **Jul. 30, 2019**

(54) **BEAD MEASUREMENT SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 101 days.

(21) Appl. No.: **15/429,782**

(22) Filed: **Feb. 10, 2017**

(65) **Prior Publication Data**

US 2017/0234677 A1 Aug. 17, 2017

Related U.S. Application Data

(60) Provisional application No. 62/294,733, filed on Feb.
12, 2016.

(51) **Int. Cl.**

H04N 5/247 (2006.01)
G01B 11/02 (2006.01)
G01M 17/02 (2006.01)
B29D 30/06 (2006.01)
G01B 11/06 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC **G01B 11/02** (2013.01); **B29D 30/0061**
(2013.01); **B29D 30/0681** (2013.01); **G01B**
11/026 (2013.01); **G01B 11/0608** (2013.01);
G01B 11/08 (2013.01); **G01M 17/02**
(2013.01); **G01M 17/027** (2013.01); **H04N**
5/247 (2013.01); **B29D 2030/0066** (2013.01)

(58) **Field of Classification Search**

CPC H04N 5/247; G01B 11/02; G01B 11/08;
G01B 11/026; G01B 11/0608; G01M
17/02; B29D 30/0681; B60C 15/00
See application file for complete search history.

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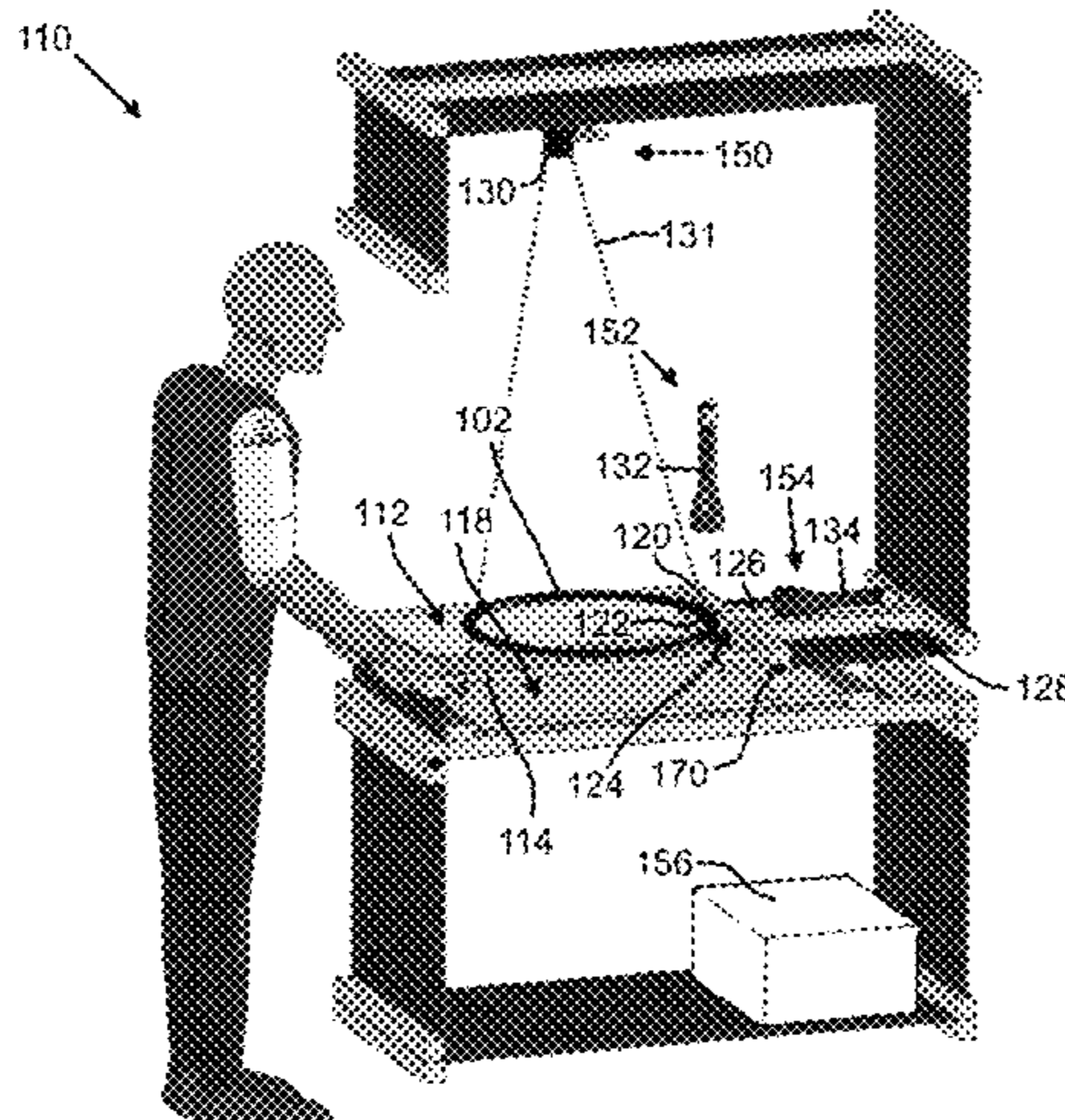
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(57) **ABSTRACT**

The current embodiments provide a system for determining
a parameter of a tire component. The system may have a
background surface, a first measurement device configured
to measure a dimension with respect to the reference surface
and a support surface located at least partially between the
first measurement device and the reference surface, where
the support surface is configured to support the tire compo-
nent. The parameter may correspond to the dimension on the
background surface.

18 Claims, 4 Drawing Sheets



- (51) **Int. Cl.**
G01B 11/08 (2006.01)
B29D 30/00 (2006.01)

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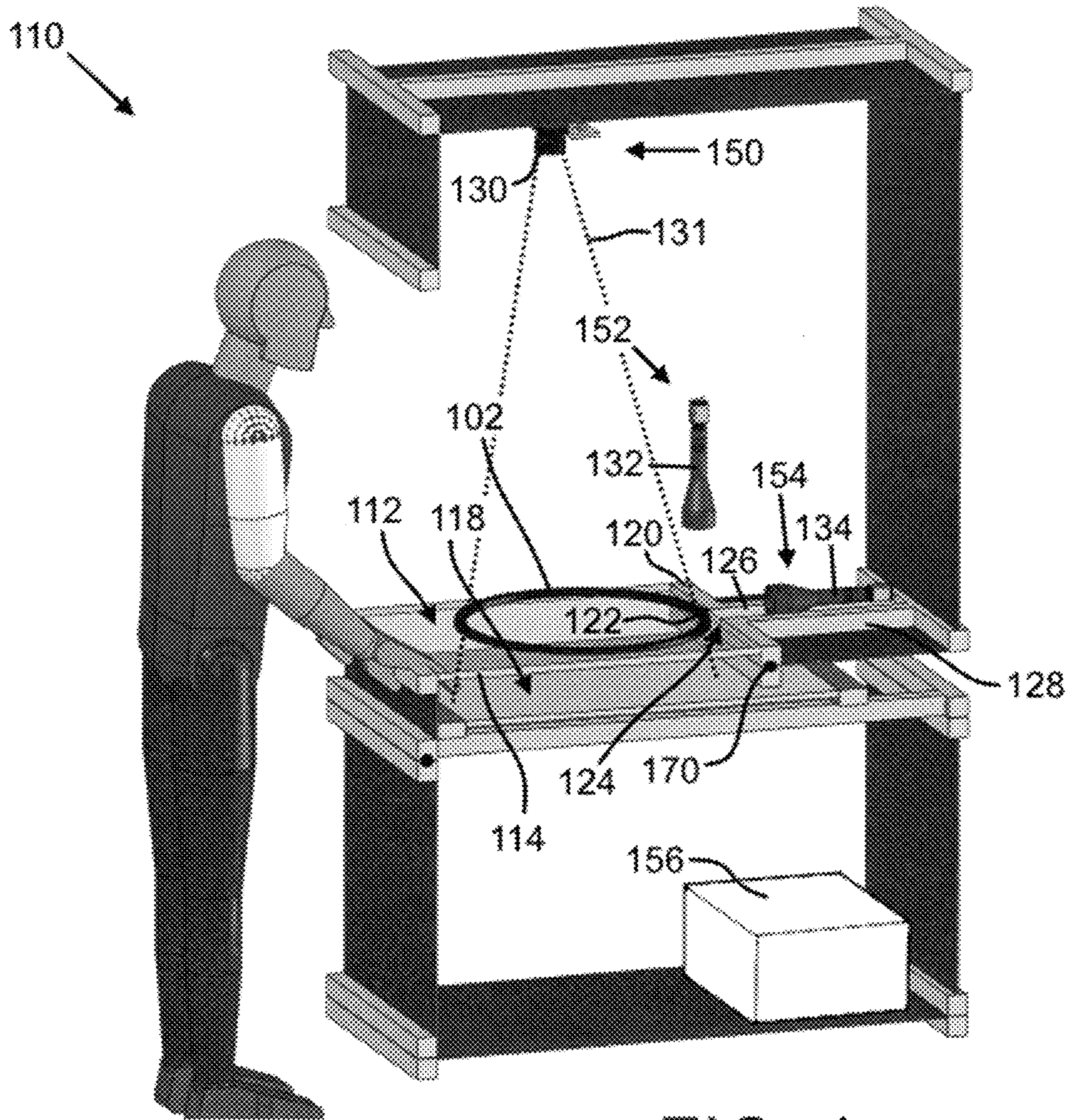
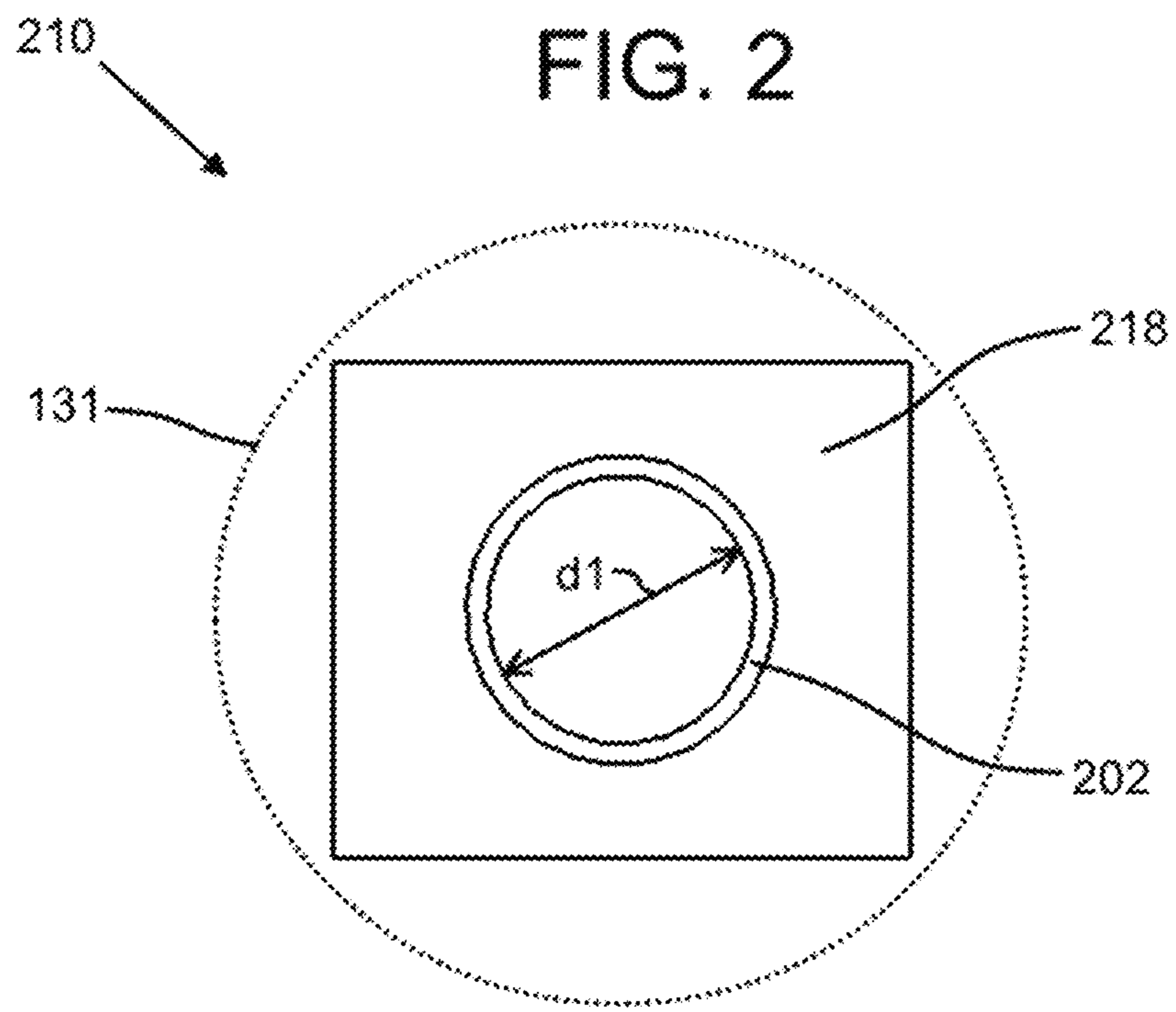


FIG. 1



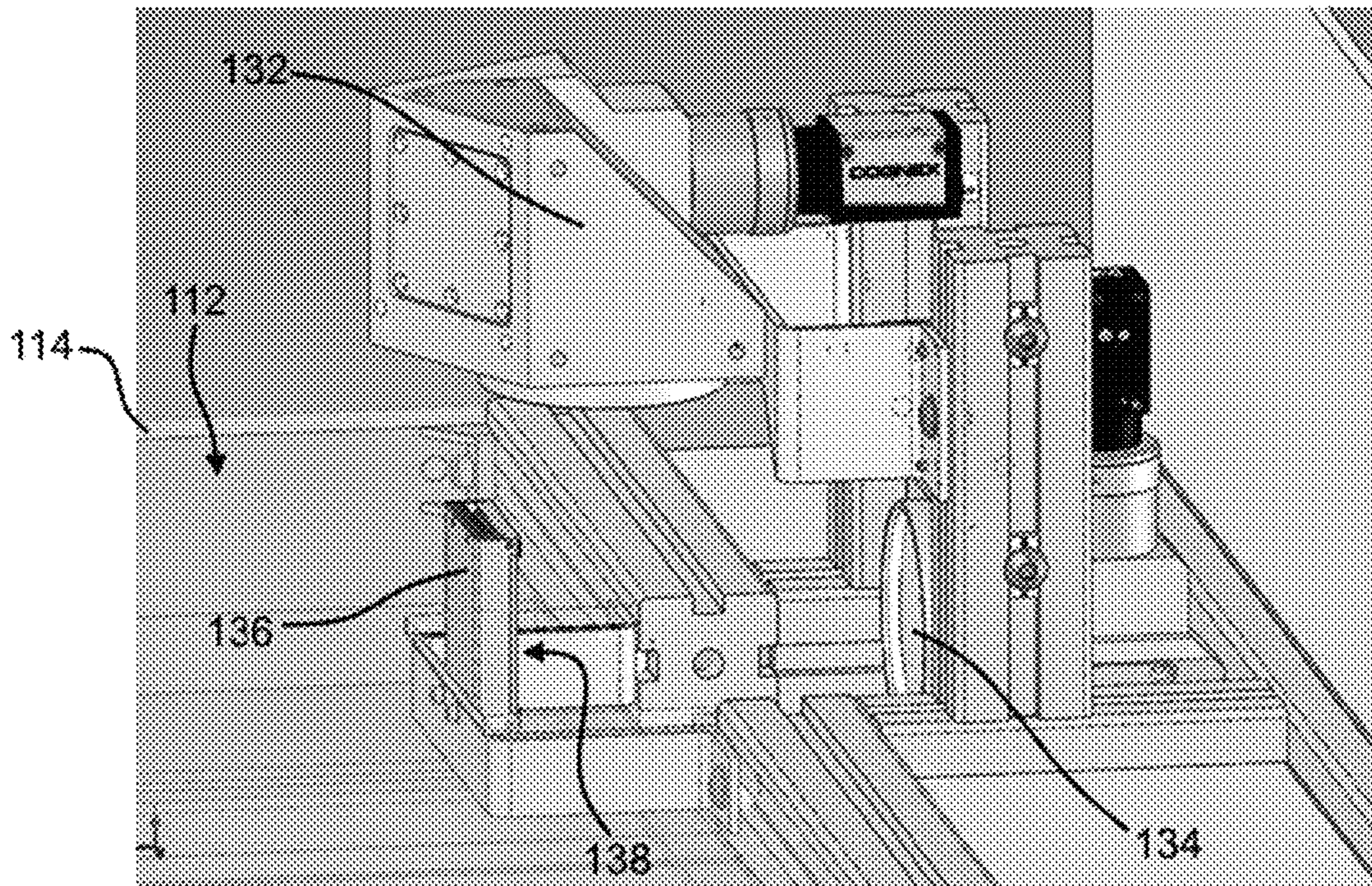
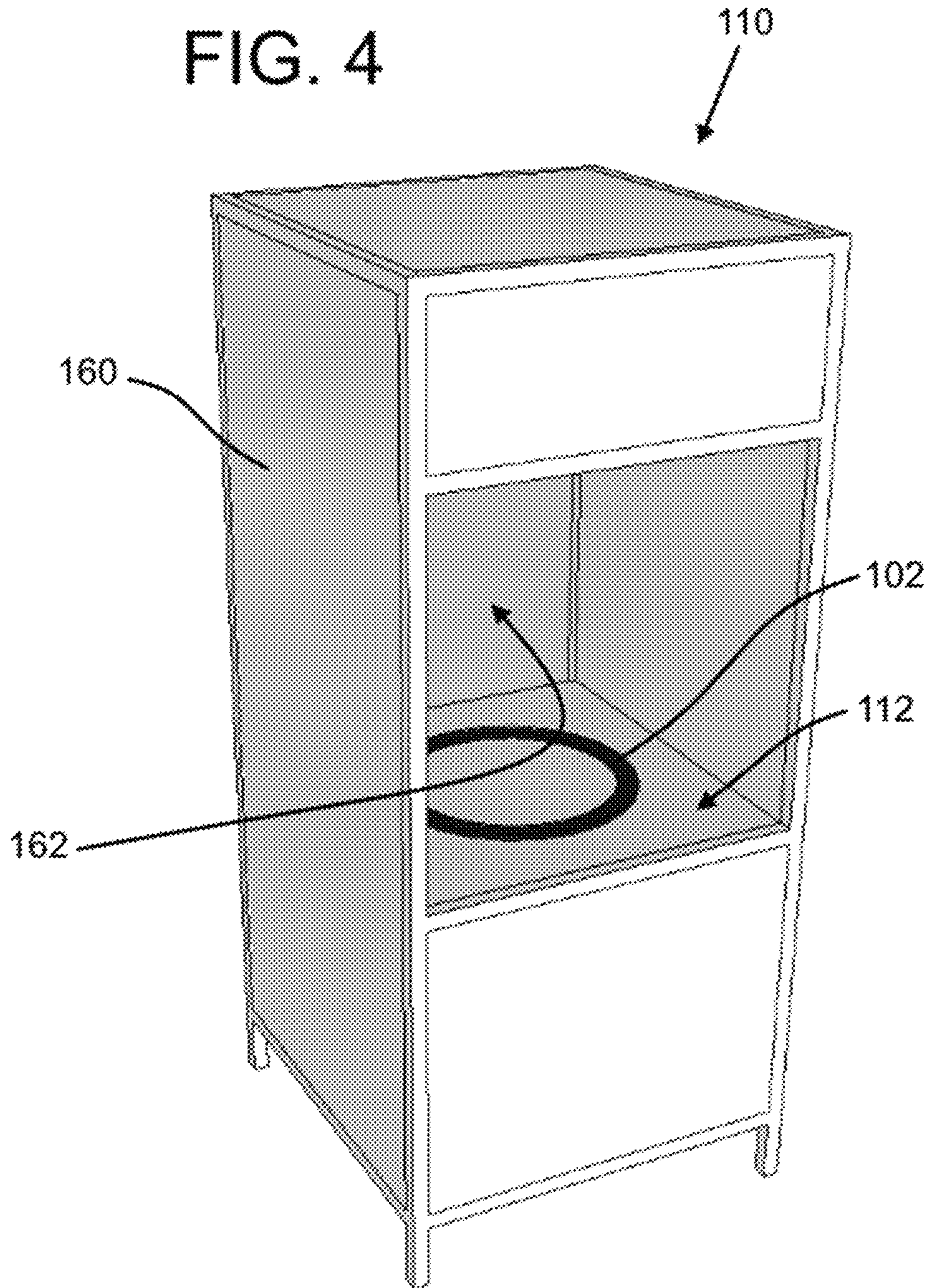


FIG. 3

FIG. 4



1**BEAD MEASUREMENT SYSTEM****CROSS REFERENCE TO RELATED APPLICATIONS**

This application claims priority to U.S. provisional application Ser. No. 62/294,733 filed Feb. 12, 2016, which is herein incorporated by reference in its entirety.

BACKGROUND

A vehicle tire generally has two annular bead rings at the innermost diameter, which provide the tire with hoop strength and structural integrity. The beads also provide stiffness at the point where the tire mounts to a rim. Beads are generally manufactured by winding metal wire in a groove on the outer periphery of a chuck or drum, often called a former. A bead may also be formed from a single wire.

Often, a single manufacturing facility may produce several types of beads with varying sizes and shapes. Several parameters of the beads are generally measured after the manufacturing process for purposes of quality control to ensure a high-quality final product. For example, certain parameters of the beads often must fall within a tolerance of 0.005 inches to meet the established quality standards. Parameters that are typically measured may include the inner diameter, height, width, and weight of the tire bead. Some existing measurement devices contact the tire bead when taking a measurement, thereby potentially distorting the tire bead during the measurement and potentially hiding defects.

It is therefore desired to provide an accurate and precise measurement system that can measure a variety of types and sizes of tire beads without undue contact to the tire bead during the measurement process.

BRIEF DESCRIPTION

The current embodiments provide a system for determining a parameter of a tire component. The system may have a background surface, a first measurement device configured to measure a dimension on the background surface and a support surface located at least partially between the first measurement device and the background surface, where the support surface is configured to support the tire component. The parameter may correspond to the dimension on the background surface.

The measurement device may have a first camera with an entocentric lens.

The system may include a second measurement device configured to directly determine a second parameter of the tire component.

The second measurement device may include a second camera having a telecentric lens.

A third measurement device may include a third camera with a telecentric lens, where the third measurement device is configured to determine a third parameter of the tire component.

At least one load cell may be positioned at least partially between the background surface and the support surface. The at least one load cell may be configured to measure the weight of the tire component.

The system may include a transparent body defining the support surface.

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The system may have at an abutment surface, wherein the abutment surface is configured to locate the tire component in a measurement position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a perspective view of an embodiment of a system for determining at least one parameter of a tire component.

FIG. 2 shows a view from the perspective of a camera with an entocentric lens when viewing a tire component located on a support surface of the embodiment of the system of FIG. 1.

FIG. 3 shows a perspective view of a portion of a system for determining a parameter of a tire component, where the system comprises an extension with a second background surface.

FIG. 4 shows a perspective view of a system for determining a parameter of a tire component with a body having a cavity.

DETAILED DESCRIPTION

FIG. 1 shows a system **110**, which may be configured to determine one or more parameters of a tire component. The tire component may be, for example, an annular body, such as a tire bead **102**. The system **110** may alternatively or additionally be configured to determine parameters of other circular or annular bodies (or bodies of another shape).

The system **110** may include a support surface **112** configured to support the tire bead **102** (or another component). The support surface **112** may be defined by a transparent body **114**, such as a sheet of glass, a sheet of transparent plastic, etc. In exemplary embodiments, the transparent body **114** is a sheet of low impurity glass (for example, an ultra-clear soda-lime float glass manufactured by Starphire). In some embodiments, the support surface **112** may include markings or other visual indicators that indicate the proper placement of the tire bead **110** during the process of determining a parameter. The transparent body **114** may be held by a frame **120**.

A background surface **118** may be included below the support surface **112**. In one non-limiting example, the background surface **118** may be substantially parallel to the support surface **112** and may be spaced approximately 4 inches from the support surface **112** (though any other suitable spacing may be used). The background surface **118** is preferably viewable from the perspective of a first measurement device **150**, which may include a first camera **130**. In addition to, or in the alternative to, the first camera **130**, the first measurement device **150** may include any other non-contact detection or measurement device (e.g., an optical sensor or the like). A backlight may be included to illuminate the background surface. In some embodiments, the background surface **118** is defined by a backlight. The background surface **118** may be configured for optimal compatibility with the first camera **130**. For example, the background surface **118** may be uniformly polished, may include a particular color, or may include other visual or other indicia that the first camera is particularly sensitive to.

The first camera **130** may be a high-resolution camera, such as a 29 megapixel Allied Vision Technologies high resolution camera with an entocentric lens such as an Edmund Optics 35 mm F-Mount lens. The first camera **130** may have any other suitable type of lens (e.g., a telecentric lens). The first measurement device **150** may additionally include image recognition and processing software, and/or

may be electrically connected to a computer **156** configured to recognize and process image data provided by the first camera **130**, to obtain a measurement. For example, the first camera **130** and the associated image recognition and processing software of the first measurement device **150** and/or the computer **156** may be configured to recognize and measure any breaks or discontinuities in the view of the background surface **118** from the perspective of the lens of the first measurement device **150** may be calibrated with respect to the support surface **112**. For example, each pixel of an image provided by the first camera **130** may be associated with a particular distance that is determined and/or set during calibration.

To illustrate, the first camera **130** may face the support surface **112** and the background surface **118** such that at least a portion of the support surface **112** and at least a portion of the background surface **118** are within the field of view of the first camera **130**. When a tire bead **102** or other component is placed on the support surface **112**, at least a portion of the background surface **118** (which, as described above, may be backlit) may be blocked from view by the first camera **130**. The image viewed by the first camera is illustrated by image **210** with a field of view **131** of FIG. 2. It is noted that the image **210** may only exist in the form of data (for example inside the measurement device **150** or the computer **156**).

The first measurement device **150** may be configured to utilize software to measure a dimension **d1**, which corresponds to the inner diameter parameter of the tire bead **102**. With reference to FIG. 2, the first portion **218** of the image **210** corresponds to the unblocked portion of the background surface **118** from the perspective of the first camera **130**, and the second portion **202** corresponds to the portion of the background surface **118** blocked from view by the tire bead **102**. The measurement device **150** and/or the computer **156** may, for example, recognize the dimension depicted as the dimension **d1** and determine its length. The first camera **130** and/or the computer **156** may additionally or alternatively be configured to recognize and measure any other dimension.

In some embodiments, the first camera **130** may have an entocentric lens providing a conical field of view (shown as the field of view **131**). Advantageously, an entocentric lens typically has a large maximum working distance (i.e., the maximum distance from the lens of the first camera **130** to the component being measured). Further, the entocentric lens may be capable of viewing a large area (particularly when placed at a relatively large distance from the support surface **112**, as the viewing area will increase with distance), thereby providing the ability for the system **110** to view and measure many different types and sizes of tire beads **102**. In one non-limiting embodiment (for illustrative purposes only), the entocentric lens of the first camera **130** may be placed approximately 36 inches from the support surface **112**, and the system **110** may be capable of measuring beads having an inner diameter ranging from approximately 12 inches to approximately 25 inches. Advantageously, many different types and sizes of beads may be measured using the first camera **130** without significant repositioning or replacement of the components of the system **110**.

The magnification effects (e.g., the reduced apparent size with increased distance) of an entocentric lens may require a measurement correction when the dimension **d1** (of FIG. 2) is measured to determine the inner diameter parameter of the tire bead **102**, for example when the minimum inner diameter of the tire bead **102** is not directly adjacent to the support surface **112** (e.g., when the tire bead **102** has a circular cross-section such that the minimum inner diameter

is a certain height above the support surface **112**). When certain variables are known (e.g., the distance from the camera lens to the support surface **112** and height of the measured dimension above the support surface **112**), the measured dimension can be converted to determine the parameter by using principles of trigonometry. In one example, the dimension **d1** of FIG. 2 corresponding to the inner diameter of the tire bead **102** can be measured by the first measurement device **150**, as described above. The dimension **d1** can then be incorporated into a mathematical sequence to determine the true size of the inner diameter parameter of the tire bead **102**. For example, when the perceived radius of the dimension **d1**, the distance of the tire bead **102** to the first camera **130**, and the height of the minimum inner diameter above the support surface **112** are known, trigonometry may be used to determine the actual inner diameter parameter of the tire bead **102**.

Referring to FIG. 1, the system **110** may additionally include a second measurement device **152** with a second camera **132** and/or a third measurement device **154** with a third camera **134**. As depicted in FIG. 1, the second camera **132** of the second measurement device **154** is oriented such that its field of view is substantially parallel to the field of view **131** of first camera **130**, though this is not necessarily required in all embodiments. Like the first camera **130**, the second camera **132** may utilize the background surface **118**. The measurement device **152** may be configured to determine a second parameter of the tire bead **102**, such as the height of the tire bead **102** as shown.

The second camera **132** may be a camera with a telecentric lens for directly measuring the second parameter (e.g., the height) of the tire bead **102**. A telecentric lens is capable of producing an orthographic view of its subject without magnification, and therefore the image magnification may be independent of the distance or position of the subject. One example of a telecentric lens that may be used is a TCCR23056 lens manufactured by Opto Engineering. The telecentric lens of the second camera **132** may be positioned above the support surface **112** such that the tire bead **102** will fall within the working range (which, for example, may be from about 1.5 inches to about 4.5 inches) of the telecentric lens when placed on the support surface **112**. Accordingly, the telecentric lens of the second camera **132** may directly measure the second parameter (e.g., height) of the tire bead **102**. Herein, the phrase "directly measure" means that a measurement may be accomplished without correcting for magnification due to distance from a lens. This direct measurement may also be independent from the position of the tire bead **102** with respect to the field of view of the second camera **132**. Advantageously, using a second camera **132** with a telecentric lens may minimize the necessity for precise placement of the tire bead **102** prior to the measurement of the second parameter, and may allow the system **110** to operate to determine the second parameter of multiple sizes and variations of the tire bead **102**. Measurement devices utilizing telecentric lenses are also typically capable of achieving highly-accurate measurements.

A third camera **134** of a third measurement device **154**, shown in FIG. 1, may be oriented such that its field of view is substantially perpendicular to the field of view of the second camera **132** and the first camera **130**. The third measurement device **154** may be configured to determine a third parameter of the tire bead **102** (e.g., a width of the tire bead **102**). Like the second camera **132**, the third camera **134** may have a telecentric lens such that the third measurement device **154** is capable of directly measuring the third parameter. Advantageously, providing a third camera **134** with a

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telecentric lens may allow for the direct determination of the third parameter of the multiple sizes and variations of the tire bead **102** and without the precise positioning of the tire bead **102** on the support surface **112**. In some embodiments, an extension **136** with a second background surface **138** may be provided. The second background surface **138** may be located generally in the field of view of the third camera **134** and may be configured for optimal compatibility with the third camera **134** and to provide contrast with respect to the tire bead **102**. Like the first background surface **118**, the second background surface **138** may be backlit and/or may be defined by a backlight.

In some embodiments, referring to FIG. 1, the system **110** may include one or more positioning devices, such one or more abutment surfaces **122** and **124**. The abutment surfaces **122** and **124** may be included on the frame **120** which at least partially supports the transparent body **114**. In addition, or alternatively, an extension may be provided from the support surface **112** (such as extension **136** shown in FIG. 3), which may include at least one abutment surface for properly positioning the tire bead **102**. The second camera **132** may be located with respect to the abutment surfaces **122** and **124** such that, when the tire bead **102** is positioned into contact with the abutment surfaces **122** and **124**, the tire bead **102** is substantially aligned with the field of view of the second camera **132** such that the second camera **132** can measure the second parameter (e.g., the height) of the tire bead **102**. Advantageously, the abutment surfaces **122** and **124** may provide simplicity in positioning the tire bead **102** correctly on the support surface **112** in a measurement system such that the system **110** can obtain measurements, thereby providing increased manufacturing efficiency and increased accuracy of the measurement results. Further, the third camera **134** may be positioned such that the tire bead **102** is at a distance within the working range of the lens of the third camera **134** when in contact with the abutment surfaces **122** and **124**. For example, this may be accomplished when the third camera **134** is positioned at least partially between two frame members **126** and **128** having the respective abutment surfaces **122** and **124**, as shown.

It is contemplated that the position of the third camera **134** may be vertically adjustable (manually or automatically) to correspond with the width of the tire bead **102** (e.g., when a tire bead **102** with a relatively large width is measured, the third camera **134** may be adjusted upward to ensure the entirety of the width of the tire bead **102** is within view of the telecentric lens of the third camera **134**). Alternatively, the position of the support surface **112** may be adjustable. In some embodiments, the size of the field of view of the third camera **134** may be sufficient such that this vertical adjustment is unnecessary.

The system **110** may have a measurement device configured to measure the mass or weight of a component placed on the support surface **112** (e.g., the tire bead **102**). For example, as shown in FIG. 1, at least one load cell **170** may be operably connected to the support surface **112**. The load cell **170** may be placed underneath the frame **120**, which supports the transparent body **114**. In exemplary embodiments, one load cell may be placed under the frame **120** supporting the transparent body **114** at positions corresponding to each of the four corners of the transparent body **114**. When multiple load cells are used, the sum of the forces on the calibrated load cells (i.e., the total force minus the weight force provided on the load cells when no component is placed on the support surface **112**) will correspond to the weight of the tire bead **102** (and/or another component)

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placed on the support surface **112**. The load cells may provide the measured weight to the computer **156**.

In some embodiments, and as depicted by FIG. 4, the system **110** may include a body **160** with a cavity **162**. As shown, the support surface **112** may define at least a portion of the bottom of the cavity **162**. The first camera **130** (described above with reference to FIG. 1) may be located adjacent to the top of the cavity **162**. The second and third cameras **132** and **134** (described above with reference to FIG. 1) may be located within the cavity **162** or may be located out of the cavity **162** but face towards the cavity **162** to view a component on the support surface **112**. The cavity **162** may include a door (not shown) that may close during the measurement of the tire bead **102** or other component. Advantageously, enclosing the cavity **162** during the measurement of at least one parameter may substantially keep ambient light from the cavity **162**. The backlights described above may therefore be substantially the only source providing light within the cavity **162**. This may decrease interruption by ambient light and increase the accuracy and precision of the above-described measurement devices. It is contemplated that the walls and other surfaces within the cavity **162** may be optimized such that reflections of the light provided by the backlights are substantially eliminated or otherwise do not interfere with the operation of the cameras.

It is contemplated that, in some embodiments, the system **110** described above may be a part of a larger assembly line where tire beads are placed on the support surface **112** (of FIG. 1) automatically, for example through the use of a conveyor system. Further, in some embodiments, the body **160** of the system **110** (shown in FIG. 4) may have castors and therefore may be movable, which may be advantageous for storage and portability in a manufacturing environment.

The current embodiments are advantageous, as they may provide the measurement of physical parameters of a tire component (such as the inner diameter, height, width, and weight of a tire bead) without distorting its form during the measurement process. This results in a highly accurate and precise measurement. Further, a single system can be utilized to measure the parameters of a variety of different sized components. Further, the tire component may be easily and quickly placed into the system and removed.

We claim:

1. A system for determining at least one parameter of a tire component, the system comprising:
 - a background surface;
 - a first measurement device configured to measure a dimension on the background surface; and
 - a support surface located at least partially between the first measurement device and the background surface, the support surface configured to support the tire component,
- wherein the support surface is at least partially transparent such that the first measurement device detects light illuminating the background surface,
- wherein the background surface is located below the support surface such that the background surface is spaced from the support surface, and
- wherein the tire component comprises a first parameter, and wherein the first parameter corresponds to the dimension viewed with respect to the background surface by the first measurement device via detection of the light illuminated from the background surface.
2. The system of claim 1, wherein the first measurement device comprises a first camera with an entocentric lens.

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3. The system of claim 2, further comprising a second measurement device configured to directly determine a second parameter of the tire component.

4. The system of claim 3, wherein the second measurement device comprises a second camera having a telecentric lens.

5. The system of claim 4, further comprising a third measurement device, the third measurement device comprising a third camera having a telecentric lens, wherein the third measurement device is configured to determine a third parameter of the tire component.

6. The system of claim 1, further comprising at least one load cell positioned at least partially between the background surface and the support surface and configured to measure the weight of the tire component.

7. The system of claim 1, further comprising an abutment surface, wherein the abutment surface is configured to locate the tire component in a measurement position.

8. A system for determining at least one parameter of a tire bead, the system comprising:

a support surface for supporting the tire bead; and
at least one non-contact measurement device, the at least one non-contact measurement device configured to measure a first dimension corresponding to a first parameter of the tire bead and a second dimension corresponding to a second parameter of the tire bead while the tire bead is supported by the support surface; and

a background surface, wherein the at least one non-contact measurement device is configured to measure a dimension viewed on the background surface by the at least one measurement device,
wherein the background surface is spaced vertically relative to the support surface, and
wherein the support surface is at least partially transparent such that the at least one non-contact measurement device detects light illuminating the background surface during measurement.

9. The system of claim 8, wherein the at least one measurement device comprises a first camera with an entocentric lens.

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10. The system of claim 8, wherein the distance between the background surface and the support surface is at least about 4 inches.

11. The system of claim 8, wherein the at least one measurement device comprises a first measurement device and a second measurement device, and wherein the second measurement device is configured to directly determine the second parameter of the tire bead without contacting the tire bead.

12. The system of claim 11, wherein the second measurement device comprises a second camera having a telecentric lens.

13. The system of claim 8, further comprising a load cell operably coupled to the support surface.

14. A method of determining a parameter of a tire component, the method comprising:

supporting the tire component on a support surface;
viewing a background surface with a first camera, wherein the support surface is located at least partially between the background surface and the first camera, and wherein the background surface is located below the support surface such that the background surface is spaced from the support surface;

measuring a first dimension of a blocked portion of the background surface from the perspective of the first camera, wherein the support surface is at least partially transparent such that the first measurement device detects light illuminating the background surface during measurement; and

determining a first parameter based on the first dimension.

15. The method of claim 14, wherein the camera comprises an entocentric lens.

16. The method of claim 14, further comprising directly measuring a second parameter of the tire component with a second measurement device.

17. The method of claim 16, wherein the second measurement device comprises a camera with a telecentric lens.

18. The method of claim 14 further comprising measuring the weight of the tire component with a load cell, the load cell being operably coupled to the support surface.

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